NACA

RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

LARGE-SCALE FLIGHT MEASUREMENTS OF ZERO-LIFT DRAG AT MACH

NUMBERS FROM 0.90 TO 1.95 OF A $\frac{1}{14}$-SCALE MODEL OF THE

NORTHROP MX-775B PILOTLESS AIRCRAFT WITH SMALL BODY.

By Warren Gillespie, Jr. and Richard G. Arbic

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON

AUG 17 1950

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

LARGE-SCALE FLIGHT MEASUREMENTS OF ZERO-LIFT DRAG AT MACH

NUMBERS FROM 0.90 TO 1.95 OF A $\frac{1}{14}$ - SCALE MODEL OF THE

NORTHROP MX-775B PILOTLESS AIRCRAFT WITH SMALL BODY

By Warren Gillespie, Jr. and Richard G. Arbic

SUMMARY

A flight test was made at high subsonic, transonic, and supersonic speeds and at high Reynolds numbers to determine the zero-lift drag of a $\frac{1}{14}$ - scale model of the Northrop MX-775B pilotless aircraft with small body. The triangular wing of the model had $67\frac{1}{2}^{\circ}$ leading-edge sweep and 15° trailing-edge sweep. The wing airfoil sections were modified NACA 0004 sections.

The drag coefficient based on total wing area was 0.0107 at Mach number 1.60. At transonic speeds the maximum drag coefficient was 0.0125. The force-break Mach number was 0.98.

INTRODUCTION

At the request of the Air Materiel Command, U. S. Air Force, the Langley Pilotless Aircraft Research Division is investigating the aerodynamic characteristics of the Northrop MX-775B pilotless aircraft through the use of rocket-propelled scale models. Continuous data are obtained from high subsonic to supersonic speeds at high Reynolds numbers.

This paper presents zero-lift drag data for a $\frac{1}{14}$ - scale model of the Northrop MX-775B pilotless aircraft with small body. The Mach number range was 0.90 to 1.95. Reynolds number, based on the wing mean aerodynamic chord of 2.31 feet, varied from 8.5×10^{6} to 29.0×10^{6}.

SYMBOLS

C_D drag coefficient (Drag/qS)

C_N normal-force coefficient (Normal force/qS)

q dynamic pressure, pounds per square foot ($\rho V^2/2$)

ρ air density, slugs per cubic foot

V velocity, feet per second

M Mach number (V/c)

c speed of sound, feet per second

R Reynolds number ($\rho V \bar{c}/\mu$)

μ coefficient of viscosity, slugs per foot-second

S wing plan-form area (including area within the body), 5.61 square feet

$\bar{c}$ wing mean aerodynamic chord, 2.31 feet

MODEL AND TESTS

The model of the present test was a $\frac{1}{14}$ - scale model of the Northrop MX-775B pilotless aircraft with small body. The model was designed to obtain zero-lift drag information during the coasting flight of the model.

The body and wing profile coordinates and the general arrangement of the test configuration are presented in table I and figure 1, respectively. Photographs of the model and model-booster combination are shown in figures 2 and 3. The body of the model had a fineness ratio of 15.6 with body frontal area 1.27 percent of the wing area. The triangular wing had $67\frac{1}{2}^{\circ}$ leading-edge sweep, 15° trailing-edge sweep and modified NACA 0004 airfoil sections in the streamwise direction. The wing chord plane was 1 inch below the body center line and parallel to it. The vertical tail had 0° sweep at the 50-percent-chord line, a taper ratio of 0.23, and 3-percent-thick symmetrical diamond airfoil sections which were modified by the addition of a constant thickness

of 0.03 inch along the chord on each side from the chord plane. The resulting thickness ratios of the root and tip sections of the vertical tail were 0.037 and 0.060, respectively.

The model was of composite wood-metal construction and was instrumented with a two-channel telemeter and two accelerometers. The accelerometers were mounted to measure normal and longitudinal forces. There was no sustainer rocket in the model.

Figure 3 shows the model and external booster in the launching position of 76°. An ABL Deacon rocket motor was used which delivers approximately 6200 pounds thrust for 3.2 seconds.

Velocity was obtained from the Doppler radar and by integration of the data from the longitudinal accelerometer. Drag was obtained directly from the longitudinal accelerometer data and by differentiation of the Doppler determined velocity-time curve. Normal force was obtained from the normal accelerometer. Trajectory and atmospheric data were obtained from the radar tracking unit and by radiosonde observations.

The accuracy of the results is estimated to be:

Mach number . . . . ±0.010
C_D . . . . ±0.0005
C_N . . . . ±0.020

RESULTS AND DISCUSSION

Curves of drag coefficient, Reynolds number, and normal-force coefficient against Mach number are presented in figure 4 for the $\frac{1}{14}$-scale Northrop MX-775B pilotless aircraft model with small body. It is seen from the curve of normal-force coefficient against Mach number that the drag data were obtained very near to the desired zero-lift trim condition. The curve of drag coefficient against Mach number of figure 4 shows that the Northrop MX-775B small-body configuration has a remarkably low supersonic drag coefficient. The drag coefficient for the model was 0.0107 at Mach number 1.60. At transonic speeds the maximum drag coefficient was 0.0125. The drag coefficient had a gradual rise with Mach number, starting at M = 0.93 and broke sharply at M = 0.98.

The drag of the model tested is compared in figure 5 with the minimum drag of two similar wing-body combinations at high values of Reynolds number. The model of reference 1, which had a body of fineness ratio 10 and a 60° delta wing with NACA 65A003 airfoil sections, has a lower subsonic drag coefficient than the model of the present test. At

supersonic Mach numbers the model of reference 1 and the MX-775B model
have very nearly equal values of minimum drag coefficient. The model
of reference 2, which had a body of fineness ratio 11.3 and a 63° delta
wing with 5-percent-thick double-wedge airfoil sections, has a relatively
high subsonic drag coefficient.

In order that a comparison could be made at the value of body-wing
size of the Northrop MX-775B test model, the drag data of figure 6 were
plotted against relative body-wing size. On this basis the Northrop
MX-775B model has a higher minimum drag coefficient at both subsonic
and supersonic Mach numbers than the model of reference 1. The test
points of figure 6 at body-wing area ratio of 0.0612 are from unpublished
data for a model identical to the model of reference 1, but having one-
half the wing area.

CONCLUSIONS

At a Mach number of 1.60 the minimum drag coefficient was 0.0107.
At transonic speeds the maximum drag coefficient was 0.0125. The force-
break Mach number was 0.98.

The drag coefficient was found to be very low throughout the Mach
number range of the test.

Langley Aeronautical Laboratory
      National Advisory Committee for Aeronautics
            Langley Air Force Base, Va.

                                              Warren Gillespie, Jr.
                                          Aeronautical Research Scientist

                                              Richard G. Arbic
                                              Aeronautical Engineer

Approved:
                    Robert R. Gilruth
            Chief of Pilotless Aircraft Research Division

GMF

REFERENCES

1. Nelson, Robert L.: Large-Scale Flight Measurements of Zero-Lift Drag
     at Mach Numbers from 0.86 to 1.5 of a Wing-Body Combination Having
     a 60° Triangular Wing with NACA 65A003 Sections. NACA RM L50D26,
     1950.

2. Edwards, George G., and Stephenson, Jack D.: Tests of a Triangular
     Wing of Aspect Ratio 2 in the Ames 12-Foot Pressure Wind Tunnel.
     I - The Effect of Reynolds Number and Mach Number on the Aero-
     dynamic Characteristics of the Wing with Flap Undeflected. NACA
     RM A7K05, 1947.

TABLE I

BODY AND WING AIRFOIL-SECTION ORDINATES

Airfoil section		Body ordinates	
Station (percent chord)	Upper and lower ordinates (percent chord)	Station (in. from nose)	Radius (in.)
0	0	0	0
1.25	.6325	1.000	.259
2.50	.8660	2.000	.491
5.00	1.1900	3.000	.703
7.50	1.4000	4.000	.893
10.00	1.5550	7.375	1.386
15.00	1.7780	10.375	1.654
20.00	1.9100	13.375	1.785
25.00	1.9780	15.375	1.808
30.00	2.0000	18.375	1.808
40.00	1.9310	20.000	1.806
Straight line	Straight line	23.000	1.787
75.00	1.0420	26.000	1.748
Straight line	Straight line	29.000	1.690
100.00	0	32.000	1.615
L.E.radius: 0.178		35.000	1.526
		38.500	1.406
		42.500	1.251
		46.500	1.082
		49.078	.965
		50.078	.909
		51.078	.837
		52.078	.742
		53.078	.618
		54.078	.457
		55.078	.253
		56.078	0
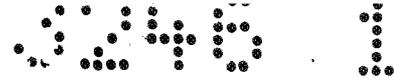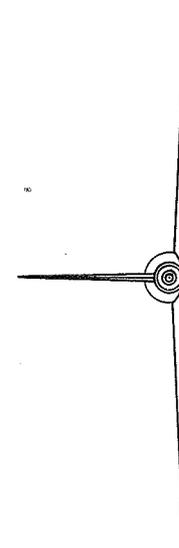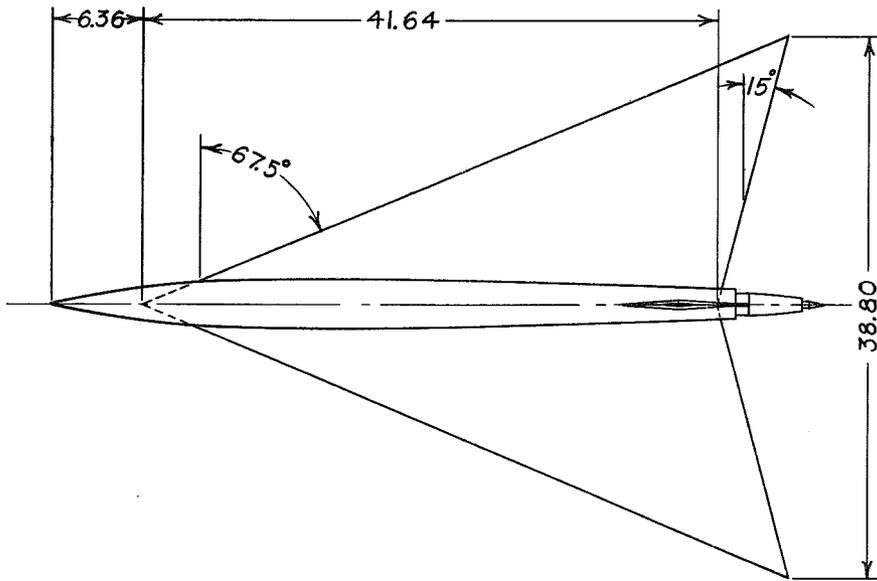
All dimensions in inches

0.030 Steel plates over
3 % diamond section

A-A

Typical fin section
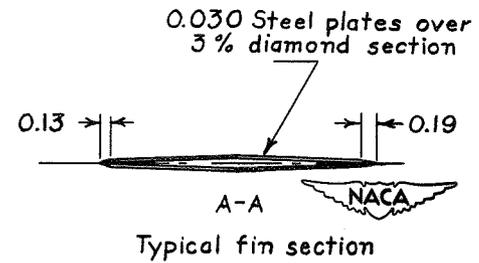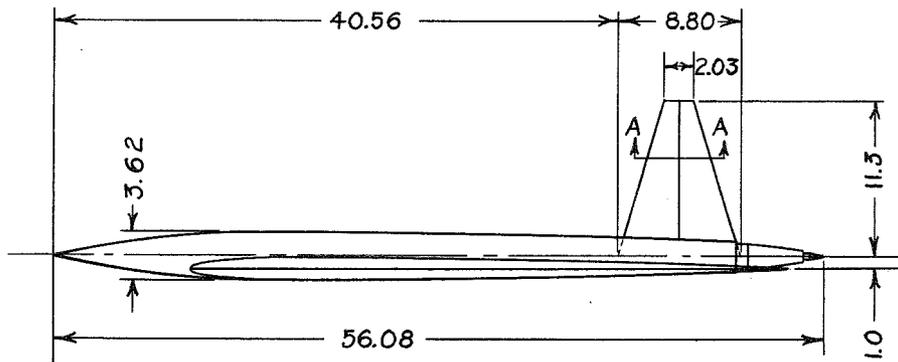
Figure 1.- General arrangement of $\frac{1}{14}$ - scale model of Northrop MX-775B
pilotless aircraft with small body.
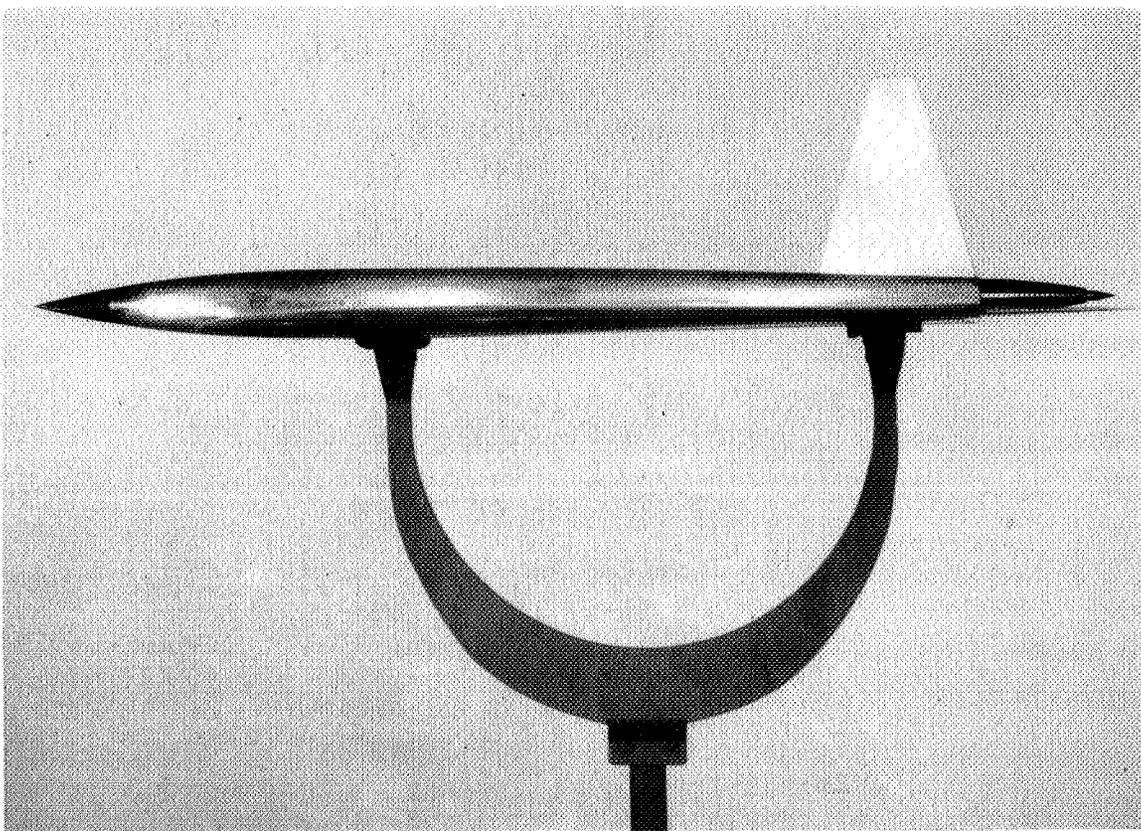
(a) Side view.
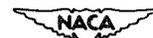
L-65632

Figure 2.- Photographs of $\frac{1}{14}$ - scale model of Northrop MX-775B pilotless aircraft with small body.
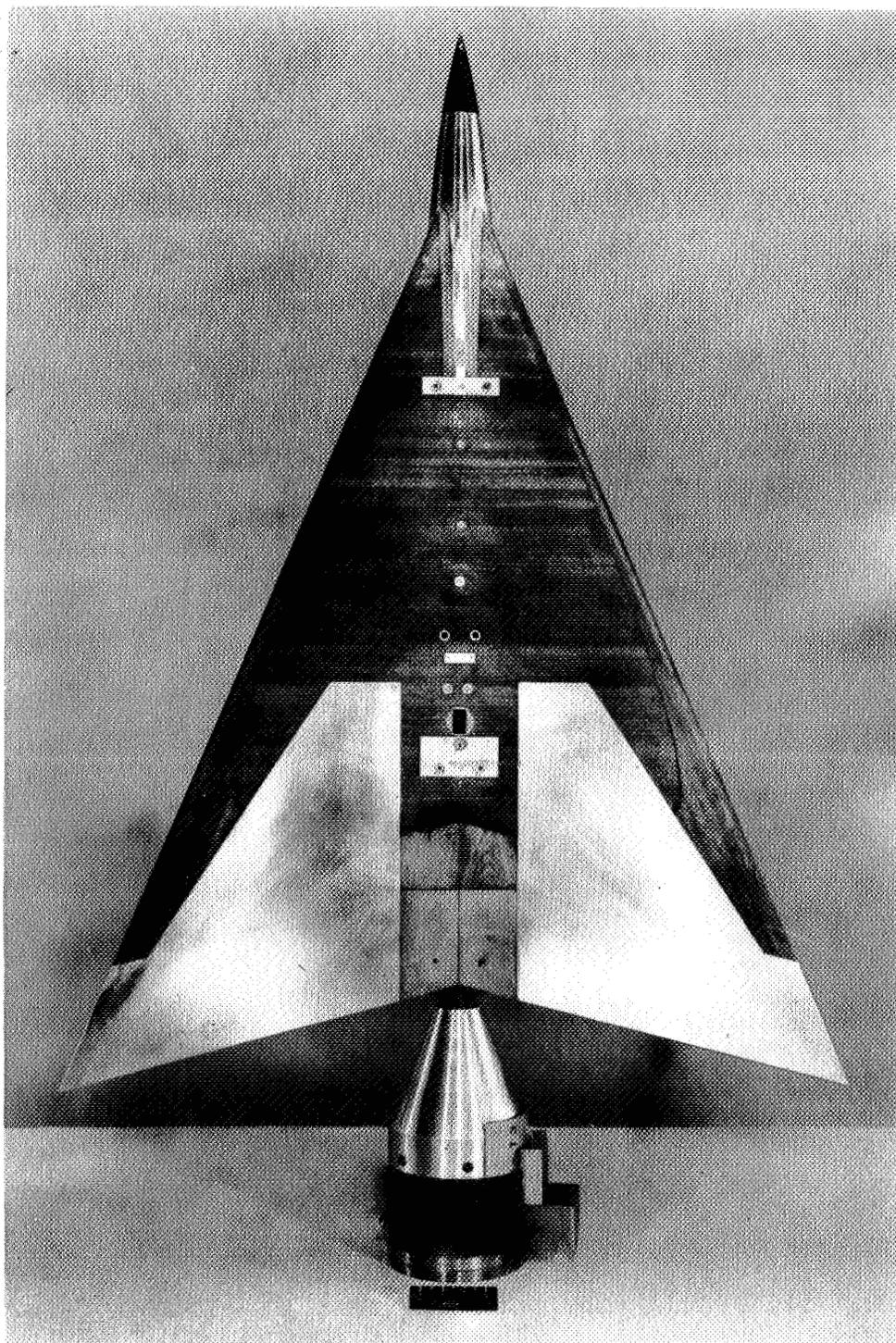
(b) Bottom view.

Figure 2.- Concluded.

L-64658
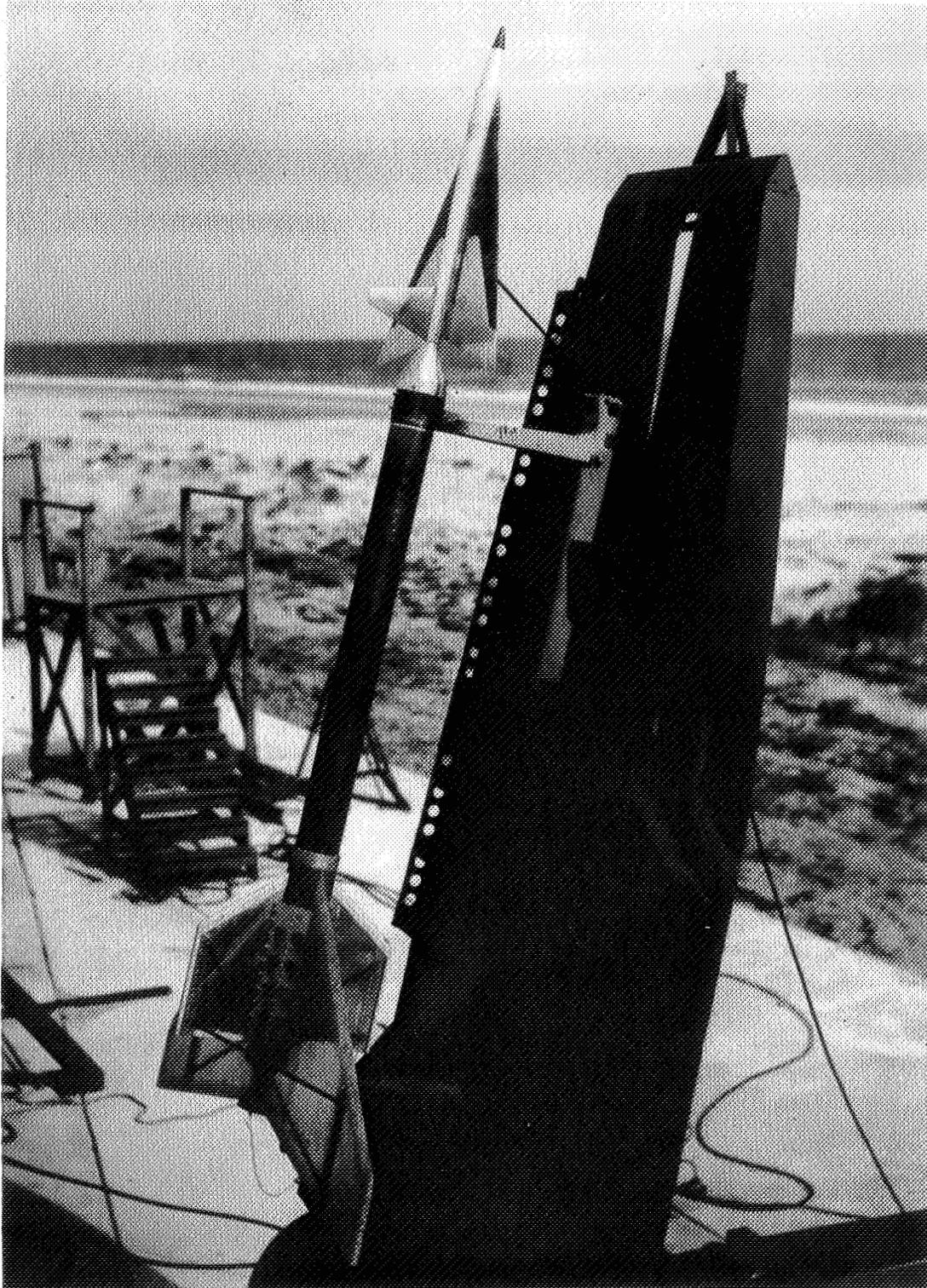
L-64694

Figure 3.- Model and booster combination in launching attitude.
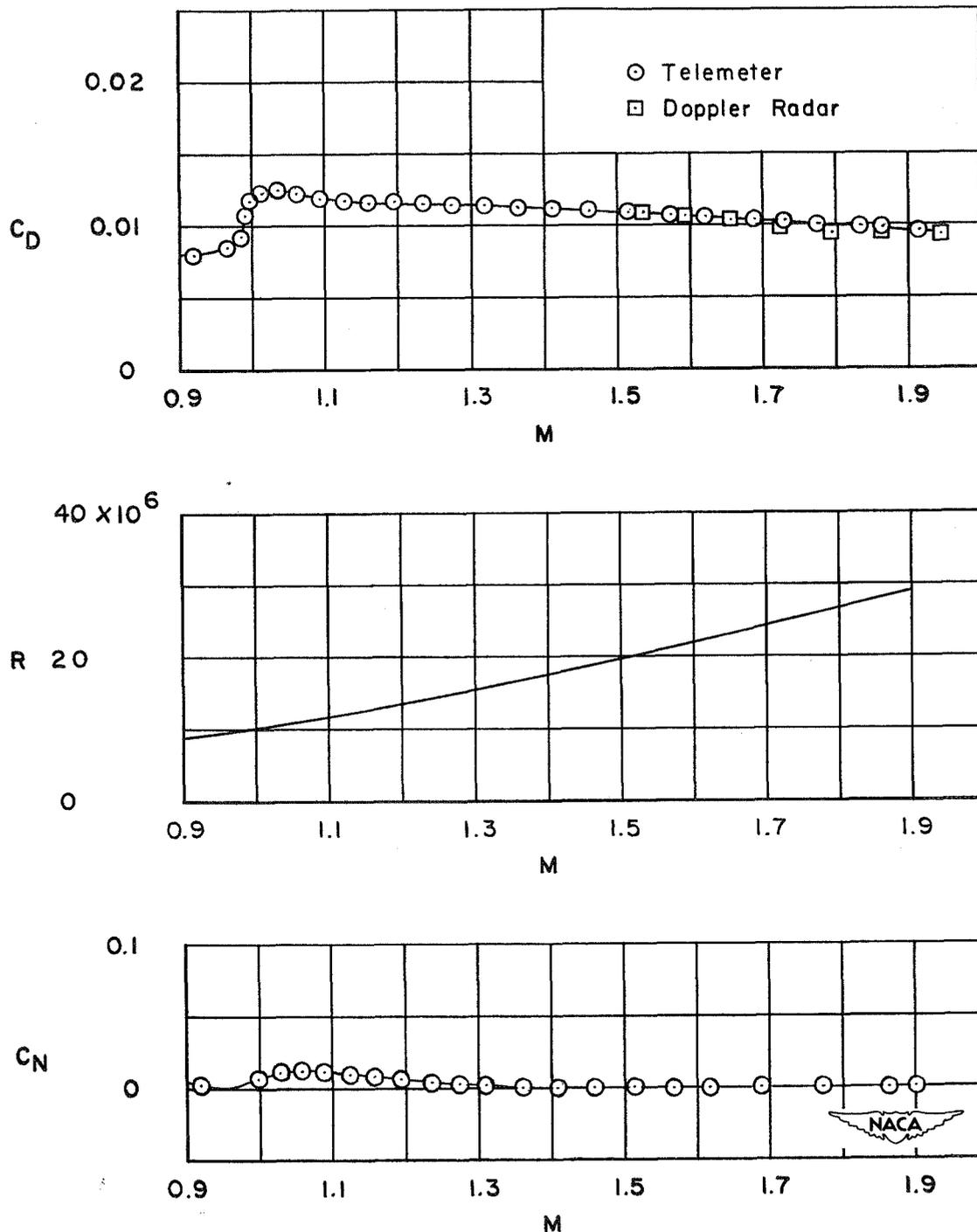
Figure 4.- Variation of drag coefficient, Reynolds number, and normal-force coefficient with Mach number for $\frac{1}{14}$ - scale Northrop MX-775B small-body model.
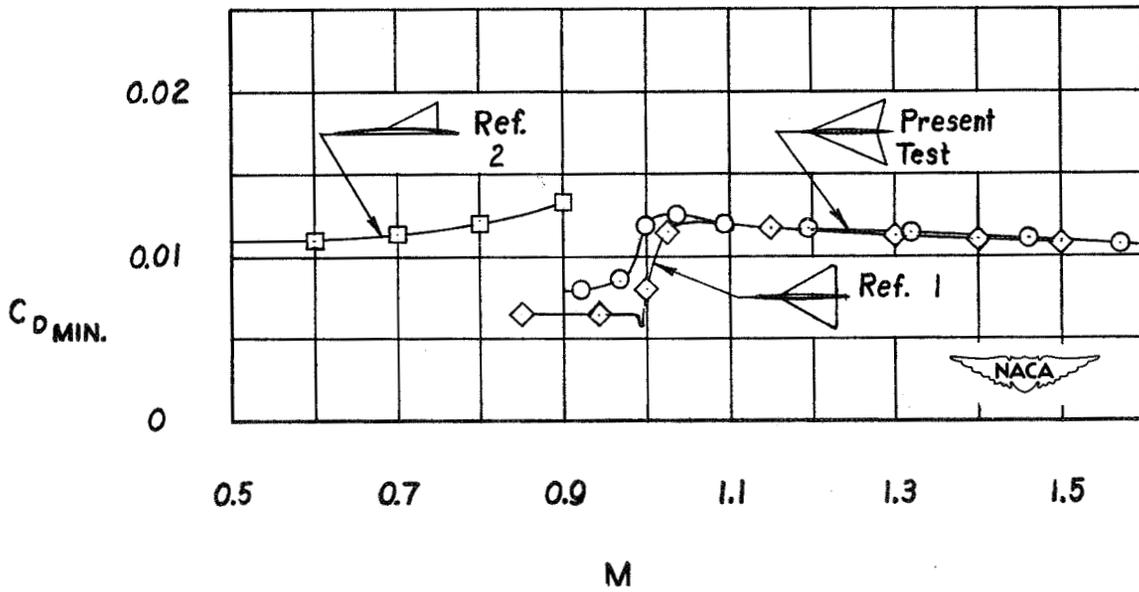
CONFIDENTIAL

Figure 5.- Variation of minimum drag coefficients of triangular wing-
body combinations at high Reynolds number with Mach number.

ERRATUM

NACA RM SL50H18 for Air Materiel Command, U. S. Air Force entitled "Large-Scale Flight Measurements of Zero-Lift Drag at Mach Numbers from 0.90 to 1.95 of a $\frac{1}{14}$-Scale Model of the Northrop MX-775B Pilotless Aircraft with Small Body," By Warren Gillespie, Jr. and Richard G. Arbic.

Figure 6 of this paper should be replaced by the corrected figure below.
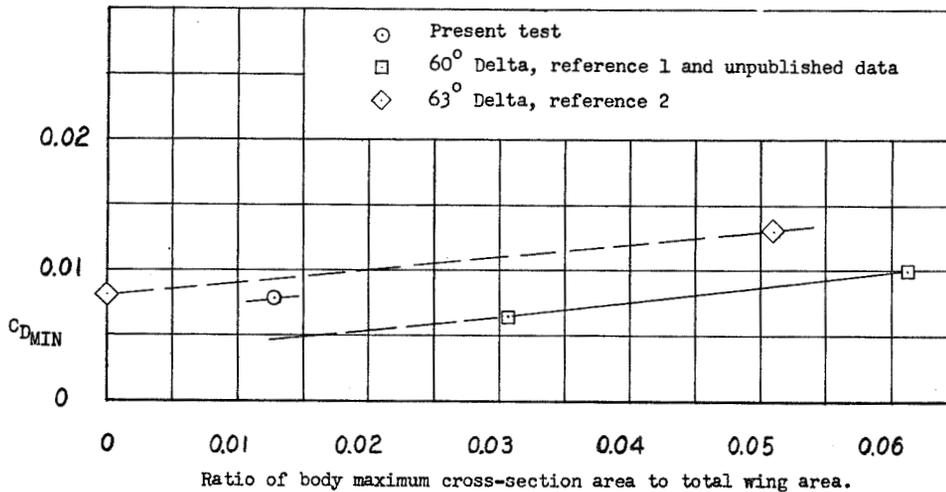

(a) Mach number 0.90.
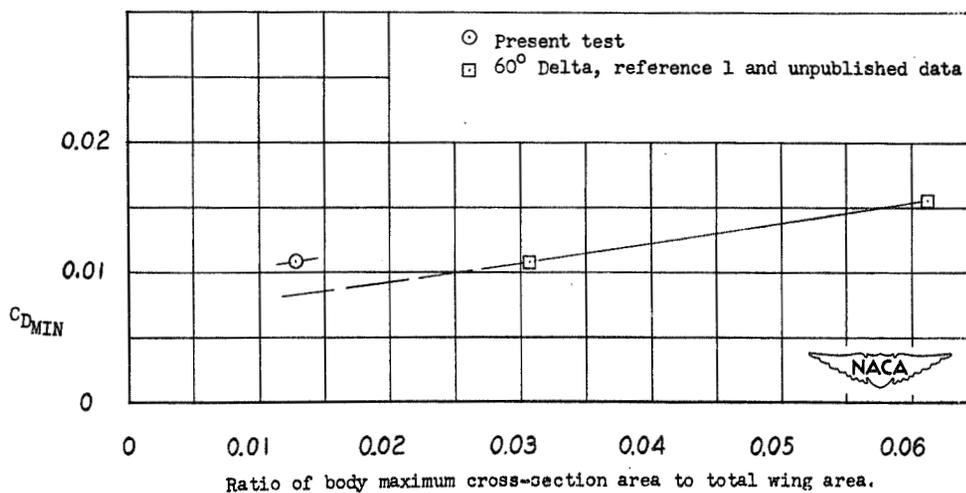
(b) Mach number 1.53.

Figure 6.- Variation of minimum drag coefficient with body-wing area ratio.

CONFIDENTIAL
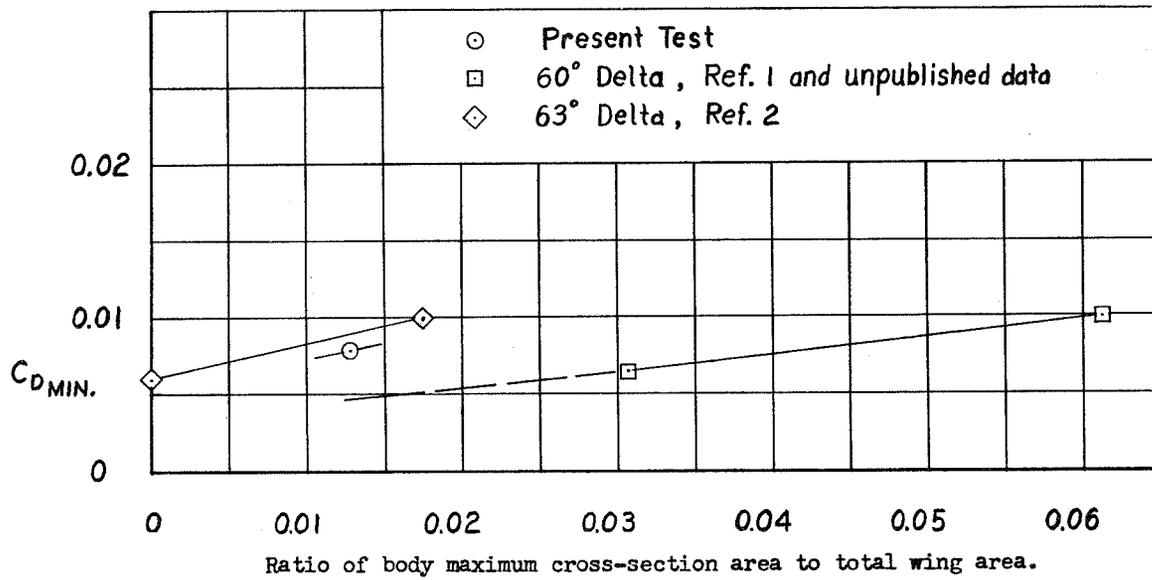
(a) Subsonic Mach number.

(b) Mach number 1.53.

Figure 6.- Variation of minimum drag coefficient with body-wing-area ratio.